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Silurian seaways and early shallow marine life

By Shadya El-Ashkar, SSU Alumna '17

During the Paleozoic Era, the eastern coast of North America was tectonically active, with multiple major mountain-building events occurring to form the Appalachian Basin. During the Silurian Period, much of the North American continent (Laurentia at the time) was covered by shallow intercontinental seaways. As a result, the environments and animal communities that existed in North America during the Silurian were different from today. For my geology master's thesis, I studied Silurian carbonate rock formations of the Appalachian Basin, from an undescribed outcrop in Bellwood, central Pennsylvania. The goal was to reconstruct depositional environments and assess how shallow marine invertebrate communities have responded to environmental shifts. The outcrop consists of the undifferentiated Mifflintown/ Bloomsburg Formations, interpreted elsewhere as representing a muddy, epeiric ramp and lower delta plain complex, respectively (Cotter, 1990). The outcrop reflects environmental transitions from open marine, muddy ramp settings to semi-restricted intertidal settings. In this context, we are using the term 'carbonate ramp' as a synonym of continental slope. Three sub-environments have been interpreted based on distinct stratigraphic and paleontological patterns: ramp, shoreface, and intertidal mudflats/lagoon.

Successions of clay-rich siliciclastic mudstones with thin fossiliferous limestone interbeds are interpreted as representing open marine, deep ramp environments (Fig. 1A). Dominance of mudstones indicates deposition below

Figure 1: Outcrop photos of the major lithologies observed in the Bellwood outcrop.

fair-weather wave base (FWWB), the deepest that waves penetrate during periods of normal weather. Occurrence of the worm-like trace fossil, Planolites, within siliciclastic mudstone layers further suggests deposition in a low-energy, oxygen-rich environment conducive for burrowing. Abundance of diverse fossil fragments and moderately poorly sorted grain textures suggest limestone beds were reworked from existing ramp material and redeposited during large storm events. Reworked limestone beds contain fragments of fossil fauna from shallower, upslope reef-building ramp communities, including Fenestrate Bryozoa, Crinoids, and Rhynchonellid brachiopods. Deep ramp communities consist of the Strophomenid brachiopods Rafinesquina and Sowerbyella. Strophomenid brachiopods are characterized by their wide hinge-lines and unique life mode; they are a group of articulate brachiopods that live unattached to a substrate – rather, these animals prefer soft, muddy surfaces in which they can bury their brachial (upper) valve beneath the sediment and filter-feed at the sediment-water interface, upside down.

At intermediate ramp depths, the lithology is dominated by a mix of silty, fossiliferous carbonate mudstones and clay-rich siliciclastic mudstones, and thin interbeds of peloidal grainstones with rare planar laminations (Fig. 1C). Based on exceptional preservation of shelly marine fauna and mixed calcareous-carbonate mudstones, deposition in a shallow ramp or open subtidal lagoon environment is the preferred interpretation. This ramp environment is characterized by communities of open marine fauna, dominated by mollusks, including orthocerid nautiloids and gastropods. Also dominant are the abundant articulate brachiopods Atrypa, and less common Damanella. This community is unique from other observed communities because it contains mobile fauna, namely the benthic gastropods and swimming predatory ortho-

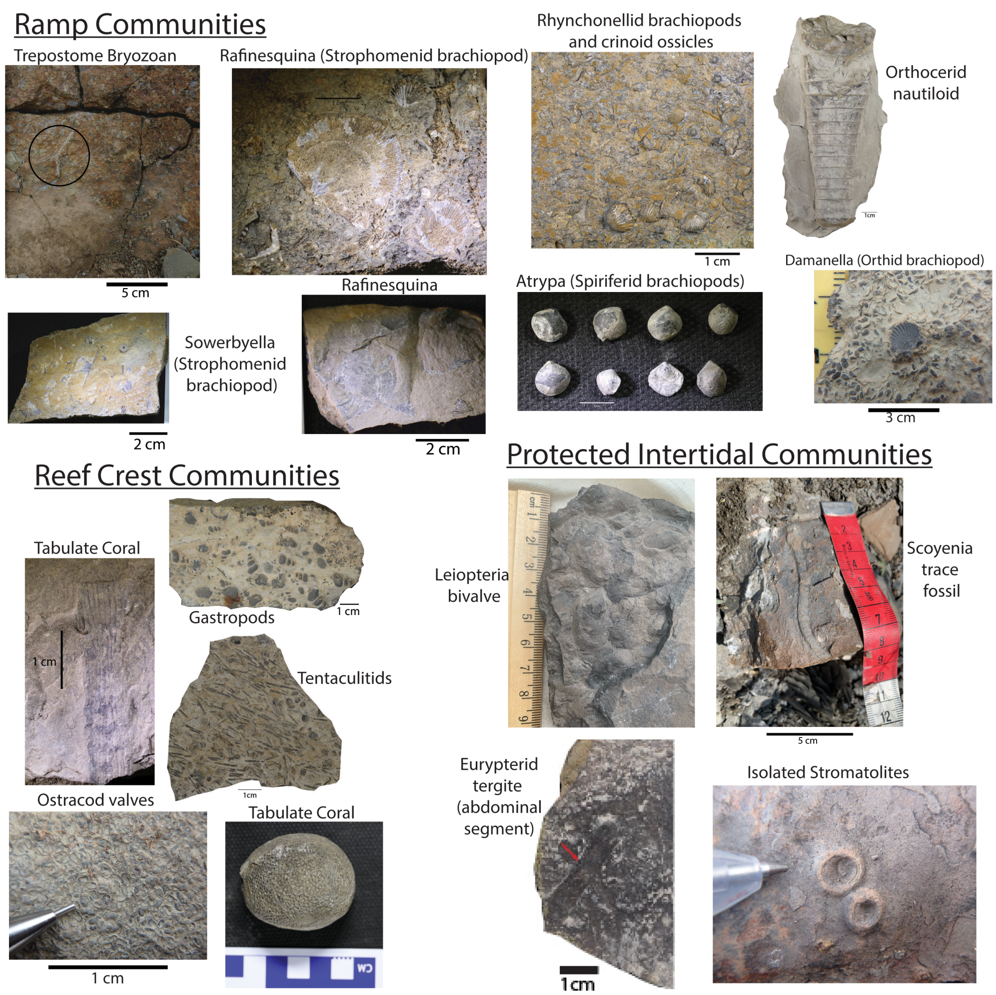


Figure 2. This figure shows some of the observed fossil specimens, grouped into their respective shallow marine environments.

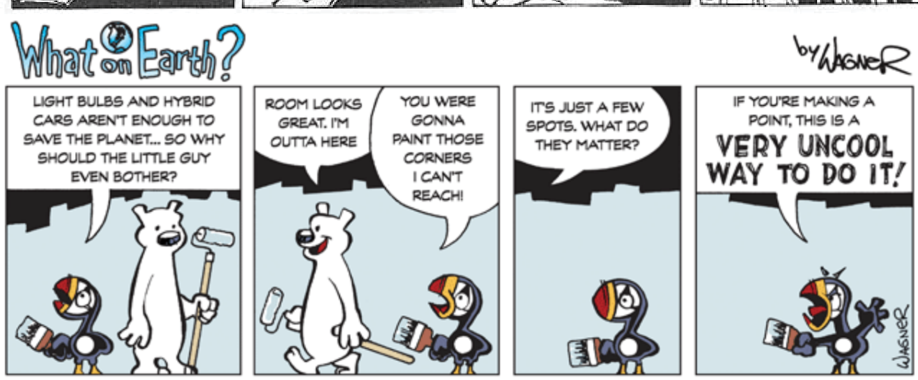
cerids, in contrast to communities of other environments which are dominated by sessile, stationary fauna. The orthocerid ecological niche is vastly different from all other observed fossil organisms; it is a pelagic, nektonic predator.

Shallow, shoreface environments are reflected by rocks with high concentrations of sand and peloids, and great fossil diversity (Fig. 1D). Planar to ripple-laminations indicate deposition above FWWB. Given the high degree of fossil fragmentation and shelly lags, this deposit is interpreted as representing reef shoals, containing fossil fauna transported and reworked from reef crest environments, likely by storm waves. Reef crest faunal communities are dominated by typical early Paleozoic reef-builders: tabulate corals, sponges, crinoids, and bryozoans. Other faunas include Rhynchonellid brachiopods, gastropods, ostracods, trilobites, and tentaculites. Early Paleozoic reef systems were much different from modern reefs. Although sponges, crinoids, and bryozoa still exist today, they are much smaller in number, many having been forced out of their reef niches by new, emerging fauna. Today, tabulate corals are extinct and reef systems are dominated by Scleractinian corals.

The intertidal environment is represented by reddish-brown calcareous mudstones, dark gray to black siliciclastic mudstones, and massive beds of lithologically variable carbonates (Fig. 1E). Carbonate beds are micritic and generally void of body fossils, suggesting deposition in a protected low-energy environment. Fossil communities exhibit low diversity but high abundance, supporting the interpretation for a protected intertidal environment. Fauna observed within these environments are generally tolerant of brackish water or stressed conditions, including the bivalve Leiopteria, ostracods, gastropods, isolated stromatolites, and potentially Eurypterids, based on a fossil fragment (Figure 2). Inarticulate brachiopod, Lingula, may have also been present, based on occurrence of Scoyenia trace fossils.

In summary, paleoecological assessments are important for understanding how environmental changes have impacted life through time. The processes and conditions within an environment play a significant role in shaping the biodiversification of communities, as well as individual groups (i.e. species). My research on Silurian paleoecologies has highlighted clear differences in faunal composition of shallow marine invertebrate communities among different shallow marine environments, as well as between the Silurian period and modern times.

Sources: (1) Cotter, Edward, 1990, Storm Effects on Siliciclastic and Carbonate Shelf Sediments in the Medial Silurian Succession of Pennsylvania: Sedimentary Geology, v. 69, p. 245-258.



Malachite!

Mineral of the Month

By Kristen Anastopoulos

Malachite is a green copper carbonate mineral with the formula, $Cu_2(CO_3)OH_2$ and is one of the first ores used to produce copper metal. Malachite occurs worldwide in locations including Gabon, Zambia, Congo, Australia, Mexico and the Urals region in Russia. The name was derived from the Greek word for mallows, alluding to its green color. Malachite has been popular in the gemstone world for thousands of years and is still a popular mineral to add to any collection. It is often cut into cabochons and beads to be made into jewelry. Due to it being a 3.5-4 on Moh's hardness scale, it is often used for sculptures and has been used as green pigment in paintings for thousands of years.

Malachite is forming above the oxidizing zone of copper at shallow depths within the Earth; it precipitates from a solution into fractures and cavities of a host rock, commonly limestone. Malachite is a common secondary mineral with a variable crystal habit, ranging from botryoidal to a fibrous. It is most often found in association with lesser amounts of Azurite Bornite, Calcite, Chalcopyrite, natural Copper, Cuprite and other iron oxides

Figure 3. Figures modified from www.mindat.org and http://www.gemcoach.com.

What is new in the ESA community?!

• Member of ESA will attend NEGSA 2021. For more info check the official website: https://www.geosociety.org

• SSU Earth Days this year focuses on the "**There is NO planet B**" theme (www.dgl.salemstate.edu/earthdays/). In conjunction with SSU Earth Days, ESA is organizing a Campus cleanup which will be held on **April 15 4:30-6PM**. Meet us in ECC Alumni Plaza. Gloves and trash bags will be provided. Join us!!

• Are you interested in having a more active role in our community? Contact us by Emailing esa.salemstate@gmail.com

• Follow us on Instagram earth_science_adventures and Facebook "*Viking Geology*" and the ESA "*Earth Science Association at Salem State University*"

• ESA is looking for volunteers to write short summary articles for future newsletters. To participate please contact us at esa.salemstate@gmail.com

Working in the environmental consulting industry as a geologist

By Sara Barrientos, SSU Alumna '16

Similar to the life of academia, the consulting industry is an environment of constant learning, as it is always adjusting to changes in legislation, new technologies and/or methodologies. However, operationally, your purpose as an environmental consultant does not change. When an environmental issue arises, you will work together with a team of geologists, engineers, and experts to resolve it within the constraints of the applicable regulatory guidance in order for your client to continue with their business and routine operations. As a new graduate, you will probably enter the industry performing field work. Know that you will be in a good position having graduated from a Geology Department that positively challenges you throughout your college career. I myself feel fully confident in my skills as a field geologist after having attended SSU.

At the beginning, a Project Manager will assign you field duties and they will ask you if you have any questions, and more often than not, you may not know what to ask - that is ok. There will be a work plan that has been approved by your client and a government agency. Review the document, sample methodology and regulation, and take some time to do online research of the sampling technique and contaminant(s) of concern. Compare the information you were given by your Project Manager with the available information you find online and you will soon have a series of questions that your Project Manager will be able to answer. The point here is that you should and will understand why and how you are collecting the field data.

Figure 4. Soil stabilization of water saturated soils prior to transport.

Start building your network early on. After giving your poster presentation as part of your SSU Senior Research requirement, exchange information with other students and scope out potential employers. Once you are on the job, exchange information with the site Superintendents and Supervisors. Become affiliated to regional or national groups based on the practice area that is most interesting to you. You can change your mind about the practice area, but you will keep benefitting from these early networking efforts you have made no matter what you choose to pursue later on. As an example, I have found it useful when I am able to contact people outside of my organization and ask for recommendations on contractors or field approaches. Naturally, in time you will progress from field staff into a managerial role, and by this point, you will have a better idea of what you would like to specialize in. Although your employer should guide you and provide the appropriate training for your professional development, it is important to own your professional and personal growth by becoming familiar with applicable licenses and certificates.

Examples of attainable certifications you can pursue prior to or right after graduating University include:

- Fundamentals of Geology exam, and Practicing Geologist license for applicable states (e.g.,VT,NH, ME, NY, CT, RI). Research costs and requirements from the National Association of State Boards of Geology, or ASBOG (asbog.org)
- Wetland Delineation Certification (wetlandcert.org/overview.html)

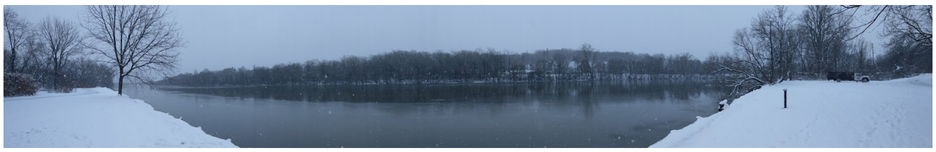


Figure 5. Groundwater monitoring well sampling.

Geology Word Search

M	I	O	O	U	T	E	R	C	O	R	E	P	T	S	T	L
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Aggregate	**Geology**	**Outer Core**
Alluvium	**Igneous**	**Petrology**
Conglomerate	**Inner Core**	**Plate**
Crust	**Lithosphere**	**Rock**
Crystal	**Loupe**	**Rock Hammer**
Earthquake	**Magma**	**Sedimentary**
Erosion	**Mantle**	**Seismology**
Fault	**Metamorphic**	**Tectonics**
Fossil	**Mineral**	**Volcano**
Gemstone	**Mining**	**Vulcanology**

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